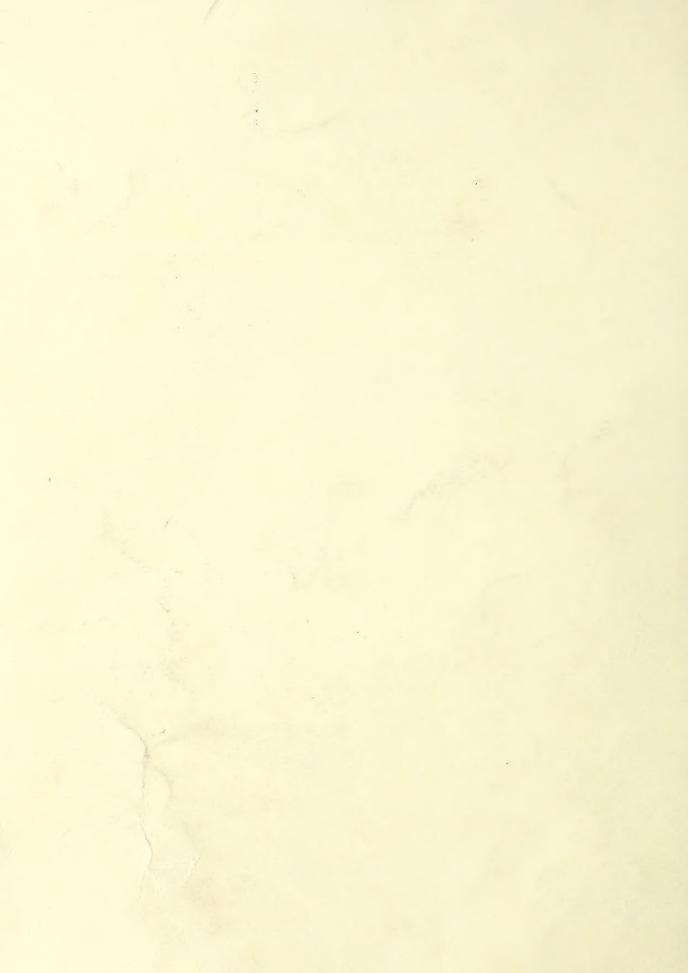
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Research Note

UNITED STATES DEPARTMENT OF AGRICULTURE FOREST SERVICE

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

No. 76

AERIAL VOLUME TABLES FOR PONDEROSA PINE TYPE IN THE ROCKY MOUNTAINS

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These aerial photo volume tables for ponderosa pine type result from the continuing research in direct photo estimating conducted at the Intermountain Forest and Range Experiment Station, Ogden, Utah. $\frac{1}{2}$

Volume estimating by direct photo measurement requires a different approach from ground cruising. Individual trees have little meaning to the photo interpreter; he sees and measures plots or stands. His estimates are most reliable when he has learned to think in terms of mean per acre volumes as they relate to the direct photo measurements of stand height, crown diameter, and crown coverage.

Photo interpreters have difficulty in identifying species on the small or medium scale photos usually available, and since many forest types contain a mixture of hardwood or conifer species, aerial stand volume tables usually are prepared as composite tables. Such tables may be for either conifer or hardwood, depending on the predominant cover, and usually are compiled from plots having a random grouping of species.

Ponderosa pine, however, occurs as a relatively pure type over extensive areas throughout the West. Although Douglas-fir and a few other conifers may be found on some north slopes, they rarely constitute more than 20 percent of the per acre volume in this so-called pure type.

The type is easy to recognize on aerial photos. Its identifying characteristic is the tendency to grow even-aged in small groups with crown cover of the dominant stand often less than 55 percent of the acre. In the more

^{1/} Moessner, Karl E. Preliminary aerial volume tables for conifer stands in the Rocky Mountains. U.S. Forest Serv., Intermountain Forest and Range Expt. Sta. Research Paper 41, 17 pp. illus. 1957.

open stands, where crown coverage of mature trees may range from 5 to 35 percent, characteristic shadows aid the interpreter in recognizing the type. Because of these silvicultural characteristics, and because tests indicate volumes significantly lower than those obtained from the composite aerial volume tables published in Research Paper 41, a separate aerial table has been prepared for ponderosa pine.

Procedure

The following tables were compiled from 84 plots measured in Idaho, Utah, Colorado, and the Black Hills of South Dakota. They relate gross board-foot and cubic-foot volumes from field measurements of 1/5-acre plots with direct photo measurements of the same plots.

Photo measurements consist of:

- 1. Average total height of the dominant stand.
- 2. Average visible crown diameter of the dominant stand.
- 3. Crown coverage of the dominant stand.

Photo measurements of total height were checked against the ground measurements of the three tallest trees on the 1/5-acre plot.

Gross volumes were computed from field data using total height-d.b.h. tables developed by Forest Survey and include:

- 1. Gross cubic volume--trees 5.0 inches d.b.h. and larger to a 4-inch top.
- 2. Gross board foot International 2-inch Rule--trees 11.0 inches and larger to a variable top with a minimum of 5.5 inches.
- 3. Gross board foot (Scribner)--trees 9.0 inches $\frac{2}{}$ and larger to same top diameters.

Volumes include cull trees and sound and cull portions of sound trees since the interpreter cannot recognize these conditions.

These tables were constructed by the alignment chart method of solving problems in multiple curvilinear correlations described by Bruce and Reineke. 3/ They are designed for use in direct photo estimates of ponderosa pine stands throughout the central Rocky Mountain areas. Use of a limited field sample should allow adjustment of these estimates to fit local areas.

²/ The 10-inch diameter class is used in many regional timber sales and accounts for the apparent inconsistency in the tables where a larger volume is shown for Scribner than for International $\frac{1}{4}$ -inch Rule, particularly in the smaller stands.

Standard Measures of Accuracy

Standard measures of accuracy for the three tables are shown in the following tabulation:

Table	Aggregate deviation	Standard error o	f estimate4/
	Percent	Units per acre	Percent
Gross volume Cubic feet	-0.31	<u>+</u> 890	<u>+</u> 40.8
Gross volume Board foot International	+1.79	<u>+</u> 5,620	<u>+</u> 54.3
Gross volume Board foot Scribner	-1.52	<u>+</u> 4,884	<u>+</u> 52.0

Tests of the Tables

A few tests of these ponderosa pine tables were made by comparing plot volumes with those obtained from field measurements and with those read from composite aerial tables published in Research Paper 41. For the most part, these plot series tests showed that mean per acre board-foot and cubic-foot volumes obtained from the ponderosa pine tables differed significantly from those obtained from the composite tables, but did not differ significantly from mean volumes obtained from ground measurements.

In addition, these tables were used by the five photo interpreters who made aerial estimates of ponderosa pine volumes on cutting compartments of the Boise Basin Experimental Forest, and on sales in the Black Hills National Forest in 1958. Summarized in a recent paper, 5 these data clearly indicate that properly trained photo interpreters using these ponderosa pine tables can make excellent aerial estimates throughout much of the ponderosa pine type.

^{3/} Bruce, D., and L. H. Reineke. Correlation alinement charts in forest research: a method of solving problems in curvilinear multiple correlation. U.S. Dept. Agr. Tech. Bul. 210, 87 pp., illus. 1931.

^{4/} Defined as the standard deviation of the difference between paired photo and field plot volumes, expressed in units per acre or as a percent of the average plot volume. The standard error of estimate indicated for these aerial tables is large because 1-acre plots measured on photos were compared with 1/5-acre plots measured on the ground. The true value of these tables is somewhat better than these errors indicate.

^{5/} Moessner, Karl E. Estimating timber volume by direct photogrammetric methods. Soc. Amer. Foresters Proc., pp. 148-151. 1959.

AERIAL VOLUME TABLE -- PONDEROSA PINE

Gross cubic-foot volume per acre by average stand height,

crown diameter, and crown cover

1- TO 10- (5) FOOT CROWN DIAMETER

21- TO 30- (25) FOOT CROWN DIAMETER

Average					Crown cover (percent)	over (p	ercent)			
height (feet)	5	15	25	35	45	55	65	75	85	95
				Ten	cubic-feet	eet				
25	1	į.	1	2	11	20	30	040	47	54
30	1	1	7	17	28	38	87	56	99	72
35	1	14	26	37	47	99	65	14	82	88
04	22	35	47	58	19	75	84	93	66	105
45	52	49	9/	87	95	103	1111	119	125	131
50	18	92	102	111	119	128	136	144	152	160
55	96	107	118	127	135	143	152	162	172	182
09	109	120	130	139	148	159	170	182	194	206
65	119	129	140	152	164	176	188	200	214	230
			11- TO	20- (15)	5) FOOT	CROWN	DIAMETER	œ		
25	;	1	1	12	22	31	040	48	55	62
30	1	7	16	28	39	84	55	62	70	78
35	10	23	36	48	58	19	75	83	06	16
04	31	44	55	99	16	84	92	66	106	113
45	19	73	84	76	103	111	119	126	132	138
20	89	100	1111	120	128	136	144	153	163	173
55	103	115	125	134	143	152	163	174	185	196
09	116	126	137	148	159	170	182	195	210	225
65	126	137	148	160	173	186	201	217	233	548
70	137	148	162	176	190	205	223	241	258	275
75	191	176	194	214	235	255	275	290	305	319
80	190	213	237	262	282	299	315	330	345	357
85	245	275	295	317	335	350	365	380	395	405
06	299	321	345	362	380	396	410	422	434	445
95	353	373	392	410	, 426	077	453	465	475	485
00	403	423	441	457	471	483	495	909	516	525
105	430	644	995	481	767	505	919	527	537	245
110	457	475	491	906	517	528	538	548	558	267
CTI	704	444	212	670	240	227	700	1/0	280	289
120	909	523	537	550	562	572	582	165	009	809

Tear Fee Fee	1	-									
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43 54 65 76 86 94 102 109 116 72 84 94 104 112 120 128 135 142 113 124 134 144 154 165 176 188 204 125 136 147 158 171 184 199 215 201 136 148 161 174 188 204 222 240 258 146 160 176 193 210 227 245 260 282 173 190 213 236 257 224 222 240 258 208 234 260 282 257 224 260 283 313 348 364 384 362 210 234 256 257 245 245 245 245 244 445 446 446 446 446	35	21	35	47	58	89	97	84	9.5	86	10.
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614 627 640 652 662 672 682 691 699 630 643 656 667 677 687 697 706 714	140	598	119	624	636	949	655	799	673	682	69
630 643 656 667 677 687 697 706 714	145	919	627	049	652	662	672	682	169	669	70
	150	630	643	959	199	677	687	269	902	714	72

Note: Stand height, crown diameter, and crown cover from photo measurements of field plots. Volumes from field measurements computed by Forest Survey total height-d.b.h. cubic-foot volume tables.

Based on 84 field plots measured in Idaho, Utah, Colorado, and the Black Hills.

Aggregate deviation: Table 0.31 percent low.

Standard error of estimate: 441 percent of the average plot volume.

Forest Survey, Intermountain Forest and Range Experiment Station, Ogden, Utah, 1958.

AERIAL VOLUME TABLE -- PONDEROSA PINE

Gross board foot volume per acre (International 1-inch) by average stand height, crown diameter, and crown cover

1- TO 10- (5) FOOT CROWN DIAMETER

21- TO 30- (25) FOOT CROWN DIAMETER

35 Hundre 13 20 41 20- (1. 20- (1. 44 44 44 57 72 95 1155	Hundre 135 8 8 13 20 41 14 44 44 57 72 72 72 72 72 72 72 72 72	Crown cover (percent)	45 55 65 75 85	board-feet	1 2 4 5 6	7 9 11	10 12 14 17 20			35 40 45 50 54	51 57 63	FOOT CROWN DIAMETER	1 2 4	5 6 8 10 12	17 20	18 21 25 30 34	32 36 41	39 44 49 54 58	54 60 66 72	92	84 91 100 108	103 110 117 126 133 137	137 144 151 158	168	215 221 226	231 237 245 254 261 265	265 273 281 288	279 287 295 304 312 318	305 314 323 332 339 345	£52 £7E 7EE
		20		Hundred	8 5 1			0	9																					

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6 8 11 14 16 17 21 25 29 33 17 22 27 32 36 40 45 33 36 41 47 53 59 65 58 33 49 55 63 69 76 83 90 98 107 80 88 99 109 117 123 130 110 119 128 137 144 150 157 142 150 159 109 117 123 130 110 119 128 137 144 150 157 142 150 167 175 182 190 110 119 128 137 144 150 157 142 150 167 175 182 190 190 142 250 258 256 257 279 </th <th></th> <th>5</th> <th>15</th> <th>25</th> <th>35</th> <th>45</th> <th>55</th> <th>65</th> <th>75</th> <th>85</th> <th>9.8</th>		5	15	25	35	45	55	65	75	85	9.8
6 8 11 14 16 19 22 11 14 17 21 25 29 33 17 22 27 32 36 40 45 27 31 36 42 47 53 59 65 71 36 41 47 53 59 65 71 49 55 63 69 76 83 90 98 107 80 88 99 109 117 123 130 110 119 128 137 144 150 188 142 150 167 175 182 190 110 119 128 167 175 182 190 110 119 128 167 175 182 190 123 220 228 244 251 259 227 238 <					Hun	dred bo	ard-fee	1			
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63 69 76 83 90 98 107 80 88 99 109 117 123 130 110 119 128 137 144 150 157 142 150 159 167 175 182 190 184 191 200 208 214 220 227 235 244 255 264 272 279 287 280 290 300 311 320 329 312 280 290 300 311 320 329 388 380 390 340 349 358 396 380 390 340 349 358 396 381 390 400 409 418 418 401 410 421 440 421 426 436 440 449 446 447 454 <t< td=""><td>65</td><td>64</td><td>55</td><td>63</td><td>69</td><td>7.5</td><td>81</td><td>88</td><td>26</td><td>105</td><td>110</td></t<>	65	64	55	63	69	7.5	81	88	26	105	110
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213 220 228 236 244 251 259 238 244 255 264 272 279 287 258 267 277 286 295 303 312 280 290 300 311 320 329 338 320 330 340 351 360 369 377 340 350 361 371 380 388 396 362 372 382 391 400 409 418 401 410 421 440 449 446 474 455 440 449 460 470 474 455 474 440 449 460 474 455 493 474	06	184	191	200	208	214	220	227	235	241	246
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320 330 340 351 360 369 377 340 350 361 371 380 388 396 362 372 382 391 400 409 418 401 410 421 431 440 447 455 420 430 440 449 458 466 474 440 449 469 476 474 455 440 449 458 466 474 440 449 478 485 493		298	308	319	330	340	349	358	368	375	380
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381 390 400 411 420 428 436 401 410 421 431 440 447 455 420 430 440 449 458 466 474 440 449 478 485 493	130	362	372	382	391	005	605	418	427	435	[77
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420 430 440 449 458 466 474 440 449 460 470 478 485 493		401	410	421	431	077	447	455	797	472	478
440 449 460 470 478 485 493		420	430	044	655	458	995	717	483	065	967
		077	677	094	025	478	485	493	205	510	516

iote: Stand height, crown diameter, and crown cover from photo measurements of field plots. Volumes from field measurements computed by Forest Survey total teight-d,b,h, board-foot (International 4-inch) table.

Based on 84 field plots measured in Idaho, Utah, Colorado, and the Black Hills.

Aggregate deviation: Table 1.79 percent high.

Forest Survey, Intermountain Forest and Range Experiment Station, Ogden, Utah, 1958.

Standard error of estimate: ±54 percent of the average plot volume.

AERIAL VOLUME TABLE -- PONDEROSA PINE

Gross board-foot volume per acre (Scribner) by average stand height, crown diameter, and crown cover

1- TO 10- (5) FOOT CROWN DIAMETER

21- TO 30- (25) FOOT CROWN DIAMETER

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	85		32	53	65	100	148	211 230	253	284	330	397	499	573			
	7.5		29	44	62	94	141	208	249	278	320	380	478	553			
	65		26	42	58	109	133	203	245	272 287	308	362	457	533			
	55	rd-feet	22	97	55	82 103	125	197	239	266	298	345	431	513			
	45	Hundred board-feet	19 .	37	52	77	118	192	235 247	260	289	332	410	493			
	35	Hund	16	34	679	73	112	187	231 243	255	282	320	391	472			
	25		13 .	31	47	67	105	180	227	250	275 291	308	373	155			
	15		10	27	45	63	98	172 202	223	245	268	320	354	429			
	5		9	23	43	59	91	162	219	239	262 275	288 308	335	407			
- pu	height (feet)		40	50	60	70	80	90	100	110	120	130	140	150			
stand	47																
sta	1																
400	95		76	17 26	36	09		9 17	27 35	43	59 72	90	135 178	205	246 257	275	
sta			7 7 9	15 17 23 26	33 36 42 43	48 50 58 60		9 9 17 17	25 27 33 35	42 43 47 48	56 59 69 72	86 90 105 110	129 135 171 178	202 205 221 224	243 246 254 257	270 275 285 290	
848	95						28					_					
43	85 95		7 6	15	33	48	DIAMETER	9	33	42	56	86 105	129	202 221	243	270	
a de la companya de l	75 85 95	feet.	6 7 8	12 15 21 23	31 33	47 48 55 58	DI	8 9 12 15	22 25 30 33	40 42 46 47	53 56 69	81 86 100 105 1	122 129 163 171	197 202 218 221	239 243 250 254	264 270 279 285	
and the second s	65 75 85 95	d board-feet	5 6 7	10 12 15 17 21 23	27 31 33 38 41 42	45 47 48 52 55 58	DI	7 8 9 10 12 15	18 22 25 27 30 33	37 40 42 44 46 47	50 53 56 61 65 69	75 81 86 94 100 105 1	115 122 129 154 163 171	191 197 202 214 218 221	235 239 243 246 250 254	258 264 270 273 279 285	
at to	55 65 75 85 95	Hundred board-feet	6 7 8 9	9 10 12 15 13 17 21 23	23 27 31 33 34 38 41 42	43 45 47 48 49 52 55 58	DI	6 7 8 9 9 10 12 15	14 18 22 25 24 27 30 33	34 37 40 42 42 44 46 47	48 50 53 56 57 61 65 69	70 75 81 86 88 94 100 105 1	108 115 122 129 144 154 163 171	184 191 197 202 210 214 218 221	230 235 239 243 241 246 250 254	253 258 264 270 266 273 279 285	
C T C	45 55 65 75 85 95	Hundred board-feet	3 4 5 6 7 5 6 7	8 9 10 12 15 10 13 17 21 23	20 23 27 31 33 31 34 38 41 42	41 43 45 47 48 47 49 52 55 58	11- TO 20- (15) FOOT CROWN DIAMETER	5 6 7 8 9 8 9 10 12 15	11 14 18 22 25 21 24 27 30 33	30 34 37 40 42 40 42 44 46 47	46 48 50 53 56 54 57 61 65 69	66 70 75 81 86 82 88 94 100 105 1	102 108 115 122 129 135 144 154 163 171	176 184 191 197 202 206 210 214 218 221	226 230 235 239 243 236 241 246 250 254	248 253 258 264 270 260 266 273 279 285	
CC 1 00	35 45 55 65 75 85 95	Hundred board-feet	2 3 4 5 6 7 5 5 6 7 8 9	7 8 9 10 12 15 9 10 13 17 21 23	17 20 23 27 31 33 28 31 42	38 41 43 45 47 48 45 47 49 52 55 58	DI	5 5 6 7 8 9 7 8 9 10 12 15	10 11 14 18 22 25 17 21 24 27 30 33	26 30 34 37 40 42 37 40 42 44 46 47	44 46 48 50 53 56 51 54 57 61 65 69	62 66 70 75 81 86 77 82 88 94 100 105 1	96 102 108 115 122 129 127 135 144 154 163 171	167 176 184 191 197 202 202 206 210 214 218 221	222 226 230 235 239 243 232 236 241 246 250 254	244 248 253 258 264 270 255 260 266 273 279 285	
stand	25 35 45 55 65 75 85 95	Hundred board-feet	1 2 3 4 5 6 7 4 5 5 6 7 8 9	6 7 8 9 10 12 15 8 9 10 13 17 21 23	13 17 20 23 27 31 33 24 28 31 34 38 41 42	35 38 41 43 45 47 48 43 45 47 49 52 55 58	DI	6 5 5 6 7 8 9 6 7 6 9 6 7 8 9 9 10 12 15	9 10 11 14 18 22 25 13 17 21 24 27 30 33	22 26 30 34 37 40 42 33 37 40 42 44 46 47	42 44 46 48 50 53 56 48 51 54 57 61 65 69	58 62 66 70 75 81 86 72 77 82 88 94 100 105 1	90 96 102 108 115 122 129 120 127 135 144 154 163 171	158 167 176 184 191 197 202 197 202 206 210 214 218 221	. 218 222 226 230 235 239 243 228 232 236 241 246 250 254	240 244 248 253 258 264 270 250 255 260 266 273 279 285	

Note: Stand height, crown diameter, and crown cover from photo measurements of field plots. Volume from field measurements computed by Forest Survey total height-d.b.h. board-foot (Scribner) volume tables.

519 562 562

Based on 84 field plots measured in Idaho, Utah, Colorado, and the Black Hills. Aggregate deviation: Table 1.5 percent low.

Standard error of estimate: ±52 percent of the average plot volume.

Forest Survey, Intermountain Forest and Range Experiment Station, Ogden, Utah, 1958.



